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Evaluation of metacognitive knowledge of 5th grade primary school students related to non-routine mathematical problems

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Abstract

Flavell (1979; 1981) considers metacognitive knowledge as one of the components of metacognition and defines it as "a person's own cognition or his general knowledge of cognition". One of the topics in which metacognitive knowledge plays an important role is mathematical problem solving. Aim of this study is to evaluate metacognitive knowledge which 5th grade primary students use. The study is qualitative and has been fulfilled in 2009- 2010 autumn semester. Some of the results obtained from the research findings are as follows: Average points of all the students for their; procedural knowledge are very high; declarative knowledge are above the mid-level; conditional knowledge are below the mid-level.

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1. Introduction

In recent studies, new terms are coming into being and some old expressions are seen redefined again (TIMSS, 2003; PISA, 2006). Among these, problem solving and metecognition are later mentioned.

1.1. Problem Solving

TDK (2005) defines problem as a question, issue or matter to be solved through theorems or rules. Two kinds of problems are mentioned in the literature (Altun, 1998):

- Routine problems: these are the ones seen mathematics books and the ones to be solved through basic operation abilities. They can be one operational or more.
- Non-routine problems: This kind of problems differs from the others in that they may not be solved through even several operations. Their solution requires a serial of activity and abilities such as operating knowledge, organizing and classifying data, being able to see the relations, finding the rules, and reaching generalities.

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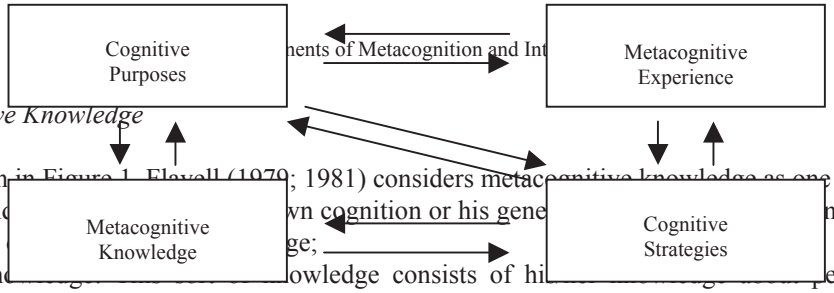
NCTM (2000) defines good problems as those "which occur in the environment where students are", "which force students to develop strategies and practice them" and "which create environments for the students to introduce new terms".

It is a fact that non-routine problems are "good problems" and hold a very important place in teaching problem solving. After all, by sassing that not to make students solve any problems other than routine ones is an "unforgivable mistake" and doing so would create a student who is lack of "imagination and judgement", Polya (1988) emphasized the importance of making students solve non-routine problems.

1.2. Metacognition

When the Greek word Meta meaning "beyond" is applied in thinking processes (meta-cognition), it means in what way a person thinks rather than thinking what a person thinks about or on what matter does he/she gain experience (Blatner, 2004).

The term metacognition evolved from the studies by Flavell (1976) on metamemory. Here, metacognition is used to define the knowledge to hold his/her own cognitive processes and knowledge and other cognitive processes under control. This term consists of what a person knows (metacognitive knowledge), what he/she can do (metacognitive ability), what he/she knows about his/her own cognitive ability (metacognitive experience). Flavell in his further studies defines metacognition as cognition and knowledge about cognitive phenomena and he clarifies its components (Flavell, 1979). According to Flavell (1979; 1981), metacognition occurs due to the controls of cognitive attempts as a result of an interaction between following components (Figure 1);



1.3. Metacognitive Knowledge

As can be seen in Figure 1, Flavell (1979; 1981) considers metacognitive knowledge as one of the components of metacognition and [illegible] cognition or his gene[illegible]n". Moreover, he talks about three types [illegible]ge;

Procedural kn[illegible]owledge consists of hi[illegible] person's fulfillment of abilities in procedures (Schraw and Moshman, 1995). In other words, It can be defined as the person's knowledge about how a task can be end up with success and how it will be done (Flavell, 1979).

Declarative knowledge: This sort of knowledge consists of his/her knowledge about the factors able to increase performance and the person himself/herself as a learner (Schraw and Moshman, 1995). In other words, It can be defined as person's knowing whether he is able to do the task and his /her knowledge about the abilities he/she owns (Flavell, 1979).

Conditional knowledge: This sort of knowledge consists of person's knowledge about when and why varies cognitive activities (Schraw and Moshman, 1995). In other words, It can be defined as person's knowledge about how the task can be performed whether he/she can perform it, and under what conditions what he/she will do (Flavell, 1979).

In addition, Flavell (1979) talks about some variables affecting metacognitive knowledge, which are interrelated with each other;

1. **Person variables:** Fundamentals of this variable consist of beliefs related with the qualification of his/her own cognitive processes. This variable can be examined in three categories:
   - *Intraindividual differences* are concerned with a person's belief about himself. For example; he believes that he learns better by listening than reading.
   - *Interindividual differences* are concerned with knowledge a person has about others which he gathers through comparisons and contrast. For example; he believes that one of his friends can remember better than the other.
   - *Universals of cognition* are concerned with the knowledge a person gain through life. For example; a person becomes aware that forgetting knowledge occurs depending on the time pass.
2. **Task variables are** concerned with belief about the nature of knowledge a person encounters and requirements of the task. For example; a person's knowledge of field related with a given mathematical problem is related with his belief of being aware of the requirements of the problem and its level of difficulty. Task variables can be examined in two sub groups (Kalafat, 2004);
   - *The nature of knowledge* which we encounter while having a task: For example, it is difficult and takes too much time for a person to understand and remember information he doesn't know through his experiences.
   - *Facts of tasks;* even though the information is the same in given tasks, solutions of some problems require more effort. For example, learning something is easier than remembering it.
3. **Strategy variables** are concerned with being aware of the strategies to use in solving problems, organizing his/her knowledge, planning its solutions, following its process, evaluating its results and knowing when and where they can be applied.

Most metacognitive knowledge actually evolve as a result of the combination and interaction of two or three of the variables mentioned above. For example, a student (person variable- different from one of his classmates) can believe that the strategy "A" (strategy variable- more than the strategy "B") should be used in the solution of the task "X" (task variable- opposite to the task "Y") (Flavell, 1979).

One of the topics in which metacognitive knowledge plays an important role is mathematical problem solving. Aim of this study is to evaluate variables affecting metacognitive knowledge and metacognitive knowledge which 5th grade primary students use to solve non-routine problems, solutions of which require a serial of activities and abilities such as being able to make generalities, finding rules, realizing relations, classifying, organizing data. Non-routine problems are different from routine problems in that they cannot be solved through choosing just one or two proper operations. With this in mind, the questioning sentence of this study is "What is the metacognitive knowledge that 5th grade primary school students use in the processes of solving non-routine problems?"

2. Method

The study is qualitative and has been fulfilled in 2009- 2010 autumn semester. Observation and interview techniques were used to collect the data. Problem solving was practiced in a randomly chosen primary school on all 5th grade students. Observations and interviews were carried out with six of them. The students were given non-routine problems, and their ways of solving them were observed. Through the interviews, it was determined what metacognitive knowledge the students used while solving the problems, what level of metacognitive knowledge they got use of, and what the variables affecting their metacognitive knowledge were. In the analysis and evaluation of the data, evaluating rubrics and observation forms prepared by the researchers were used. The practice lasted 3 weeks and total 10 non-routine problems were used.

3. Results (Findings)

In this section are given the findings and their interpretation regarding the metacognitive knowledge (Table 1), declarative knowledge (Table 2) and conditional knowledge (Table 3) that are used by 5^{th} grade primary school students in solving the non-routine problems they are assigned.

Table 1. The level of Students' Procedural Knowledge and the Variables that Affect It

Students	Procedural Knowledge Average Point	The Average Points Resulting From Students' Knowledge of Individuals Variables			The Average Points Resulting From The Students' Knowledge Of Task Variables	The Average Points Resulting From The Students' Knowledge Of Variables Of Strategy
		Students' Knowledge of Intra-individual Differences	Students' Knowledge Of Inter-individual Differences	Students' Knowledge Of Universals of cognition		
1	4,3	3,7	3,9	3,1	2,7	4,1
2	3,9	3,3	3,5	2,7	2,6	3,4
3	3,7	3,4	3,3	3,2	2,5	3,5
4	4,1	3,9	3,7	3,3	2,8	3,9
5	4,7	4,2	4,1	3,7	3	4,5
6	3,8	3,7	3,5	3,1	2,5	3,5

When Table 1 is examined, it is possible to note that the average points regarding their knowledge of procedural which they use in solving the non-routine problems are very high. In parallel with it, the students' average points regarding the individual variables that affect their knowledge of procedural are very high too. When the points regarding the individual variables are examined, the points of the students regarding their knowledge of the variables related to the individual and inter-individual differences are seen to be higher than the points regarding their knowledge of universals of cognition. In this case, it can be said that the students are aware of the cognitive processes of their own and of others' but that they have a little more difficulty in making generalizations about cognitive processes.

Again in Table 1, it is seen that the average points based on their knowledge regarding the task variables that affect their procedural knowledge are 3 or more points lower. Consequently, it is possible to state that the students have an average level of knowledge regarding this variable. In other words, the students don't have much knowledge of the nature of the knowledge they are faced with and of the requirements of the assigned task.

Again in Table 1, it is to be noted that the students' average points regarding the variable of strategy are rather higher. It can be judged as a natural result of the fact that their general average resulting from their procedural knowledge is high. In other words, it is possible to interpret this result in the way that the students are all aware of the strategies that they will use in solving problems.

Table 2. The level of Students' Declarative Knowledge and the Variables that Affect It

Students	Declarative Knowledge Average Point	The Average Points Resulting From Students' Knowledge of Individuals Variables			The Average Points Resulting From The Students' Knowledge Of Task Variables	The Average Points Resulting From The Students' Knowledge Of Variables Of Strategy
		Students' Knowledge of Intra-individual Differences	Students' Knowledge Of Inter-individual Differences	Students' Knowledge Of Universals of cognition		
1	3,3	3,5	3,4	3,2	3,7	3,5
2	3,5	3,1	3,3	2,9	3,4	3,3
3	4.1	3,6	3,7	3,5	4,1	3,8
4	3,7	3,4	3,4	3,2	3,8	3,9
5	3,2	3,1	3,3	2,7	3,5	3,5
6	3,5	3,5	3,5	3,1	3,6	3,8

When Table 2 is examined, it is possible to say that the students' average points resulting from their declarative knowledge that they use in solving non-routine problems are above the mid-level. In other words, the students, as learners, have knowledge about themselves and the factors that can enhance their performances. In parallel with it, the average points of the students regarding individual variables that affect the students' procedural knowledge are

generally higher than the average. When their points for individual variables are examined, the students' points regarding their knowledge of individual and inter- individual differences are seen to be higher than the average points regarding their knowledge of generalization about cognition. In this case, it can be said that the students have knowledge about their and others' proficiency, yet they have a little difficulty in making generalizations about cognitive processes.

Again in Table 2, it is seen that the average points of the students regarding their knowledge of the task and strategy variables that affect their procedural knowledge are above the mid-level. That is to say, they have knowledge, which we can see sufficient, about what they can do to improve themselves and about their proficiency as to what the assigned task requires, and about the nature of the knowledge related to the use of strategy in solving problems.

Table 3. The level of Students' Conditional Knowledge and the Variables that Affect It

Students	Conditional Knowledge Average Point	The Average Points Resulting From Students' Knowledge of Individuals Variables			The Average Points Resulting From The Students' Knowledge Of Task Variables	The Average Points Resulting From The Students' Knowledge Of Variables Of Strategy
		Students' Knowledge of Intra-individual Differences	Students' Knowledge Of Inter-individual Differences	Students' Knowledge Of Universals of cognition		
1	2,7	3,1	3,3	3,1	2,8	2,6
2	2,5	2,6	2,8	3,1	2,6	3,3
3	2,6	2,9	3,1	3,1	3,4	3,1
4	2,9	3,3	2,8	2,9	3,1	2,9
5	3,1	3,5	3,4	3,5	3,6	3,4
6	2,6	2,9	2,7	2,5	2,9	2,9

When Table 3 is examined, it is possible to say that the students' average points resulting from their conditional knowledge that they use in solving non-routine problems are below the mid-level. That is to say, it can be thought that the students don't have enough knowledge about what to do. In parallel with it, the average points of the students resulting from individual variables that affect the students' conditional knowledge are generally below the middle. When the points for individual variables are examined, the average points of the students resulting from their knowledge of individual and inter-individual differences and the average points regarding their knowledge of generalization about cognition are quite close to each other and below the mid-level. In this case, it can be said that the students have difficulty in making generalizations about how they themselves and others will act under different conditions and about the cognitive processes concerning different situations.

Again in Table 3, it is seen that the average points of the students regarding their knowledge of the task and strategy variables that affect their conditional knowledge are below the mid-level.

4. Conclusion

Some of the results obtained from the research findings are as follows:

- It is possible to say that the average points of all the students for their knowledge of procedural which they use in solving the non-routine problems are very high. In parallel with it, the points for the variables that affect the knowledge involved are also quite high.
- It is possible to say that the students' average points resulting from their declarative knowledge that they use in solving non-routine problems are above the mid-level. In parallel with it, the points for the variables that affect the knowledge involved are also observed to be in or above the mid-level.
- It is possible to say that the students' average points resulting from their conditional knowledge that they use in solving non-routine problems are below the mid-level. In parallel with it, the points for the variables that affect the knowledge involved are also observed to be in or below the mid-level.

References

Altun, M. (1998). *Matematik Öğretimi.* Bursa: Alfa Yayınları. 10. Baskı.

Blatner, A. (2004). *The developmental nature of consciouness transformation.* American Psychiatric Association and American Academy of Child Adolascent Psychiatry, 26(2), 2-7.

Flavel, J. H. (1976). *Metacognitive Aspects of Problem Solving*, in L. B. Resnick(Ed.), The Nature of İntelligence, pp. 231-235, Hillsdale, N. J,: Lawrance Erlbaum.

Flavel, J.H. (1979). Metacognitive and Cognitive Monitoring. *American Psycholist,* 34, 96-911.

Flavell, J. H. (1981). Cognitive Monitoring. In W. Dickson (Ed.), Children's oral communication skills. New York: Academic Press.

Kalafat, S. (2004). Üstbiliş (Metacognition). Psikoloji Portalı Sitesi http://www.e-sikoloji.com/modules.php?name=News&file=print&sid=24 25 Kasım 2006

Nctm, (2000). *Principles and Standarts for School Mathematics.* National Council of Teachers of Mathematics, Reston, VA

Pisa (2006). *The Programme for International Student Assessment 2006: Science Competencies for Tomorrow's World, Executive Summary*. OECD

Polya, G. (1988). *How to Solve It.* New Jersey, NJ: Princeton University Pres.

Schraw, G. & D. MOSHMAN (1995). *Metacognitive Theories.* Educational Psychology Rewiev, Volume: 7, Pages: 351-371

Timss, (2003). *IEA's TIMSS 2003 International Report on Achievement in the Mathematics Cognitive Domains: Findings from a Developmental Project* International Association for the Evaluation of Educational Achievement. TIMSS & PIRLS International Study Lynch School of Education, Boston College.

Türk Dil Kurumu (2005), *Türkçe Sözlük*, Ankara: Türk Dil Kurumu Yayınları; 549.